
Design Efficacy Measurement (DEM)

Phase 1. Exploratory data analysis

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Data are modified for the confidentiality purpose!

Summary



Introduce a new methodology; **Design Efficacy Measurement (DEM)** tool



How DEM is developed and what are the relevant metrics



How it can be used to monitor treatment progression quantitatively



How it can enhance the product performance and reduce DE rates during the treatment



Overall roadmap to create a treatment predictability model

Develop Design Efficacy Measurement (DEM) Methodology

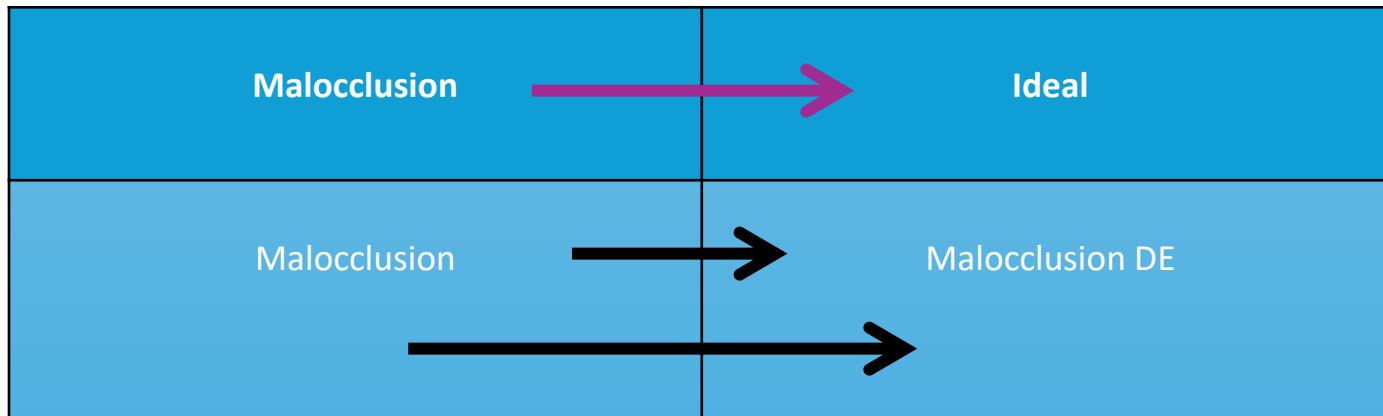
Objective:

Create a **Design Efficacy Measurement** tool or metrics to measure or/and predict treatment outcome based on design input.

Treatment goals: Moving teeth to an ideal teeth arch/location

Study Goals: To quantitatively measure the teeth movements between Initial case and the case outcome at the time of DE and compare with expected design movements

How: To calculate the Pairwise Bracket Movements between Initial case and the outcome at the time of DE



Difference Between Clinical and Design (mm)

$$\text{Difference Between Clinical and Design} = (\text{Expected Design}) - (\text{Clinical Outcome})$$

OR

Difference Between Clinical and Design =

| (Initial (Malocclusion) Bracket Distances – Ideal Bracket Distances) |

– | (Initial (Malocclusion) Bracket Distances - Malocclusion-DE Bracket Distances) |

EQC840

EQC840-DE

Arch		Upper/Mx											
Tooth Number		UR6	UR5	UR4	UR3	UR2	UR1	UL1	UL2	UL3	UL4	UL5	UL6
Height Relative to R1 (mm)		-3.47	-3.27	-3.52	-0.21	0.02	0.0	0.04	0.08	-0.09	-1.22	-1.24	-0.77
Teeth pairs		6_5	5_4	4_3	3_2	2_1	1_1	1_2	2_3	3_4	4_5	5_6	
Ideal Distance (mm)		8.2	6.62	7.13	5.95	5.95	6.66	5.83	5.76	6.18	7.47	8.01	
Malocclusal Distance (mm)		9.05	7.99	9.69	4.43	5.08	7.19	5.06	4.73	6.56	8.59	9.08	
Bonding Overstretch (mm)		0.85	1.37	2.56	1.52	0.87	0.53	0.77	1.03	0.38	1.12	1.07	
Smartwire 1 Standard Template	Wire Loop Length	10.17	9.42	11.0	9.7	9.83	9.27	9.83	9.7	11.0	9.42	10.17	
	Loop Length Max Deflection	3.4	3.21	4.37	3.23	3.17	2.78	3.17	3.23	4.37	3.21	3.4	
	Loop Length Required	7.33	7.54	8.95	8.07	7.91	7.65	7.83	7.6	6.47	7.29	7.57	
Smartwire 2 Standard Template	Wire Loop Length	8.99	8.84	10.83	8.07	8.27	7.77	8.27	8.07	10.83	8.84	8.99	
	Loop Length Max Deflection	1.96	2.06	3.56	1.48	1.7	1.56	1.7	1.48	3.56	2.06	1.96	
	Loop Length Required	6.54	6.91	8.23	7.21	6.73	5.97	6.67	6.92	6.99	6.73	6.72	
Smartwire 3 Standard Template	Wire Loop Length	8.99	8.79	10.83	8.07	8.27	7.79	8.27	8.07	10.83	8.79	8.99	
	Loop Length Max Deflection	1.97	2.2	3.72	1.79	1.73	1.53	1.73	1.79	3.72	2.2	1.97	
	Loop Length Required	6.38	6.1	7.01	6.08	6.14	5.95	6.11	5.91	6.33	6.01	6.46	

Arch		Upper/Mx											
Tooth Number		UR6	UR5	UR4	UR3	UR2	UR1	UL1	UL2	UL3	UL4	UL5	UL6
Height Relative to R1 (mm)		-3.4	-3.33	-3.49	-0.69	-0.51	0.0	0.77	0.66	1.32	-0.68	-1.05	-0.62
Teeth pairs		6_5	5_4	4_3	3_2	2_1	1_1	1_2	2_3	3_4	4_5	5_6	
Ideal Distance (mm)		7.85	6.49	6.29	5.48	5.58	6.51	5.74	5.3	5.11	6.73	7.81	
Malocclusal Distance (mm)		8.4	6.75	7.49	5.61	6.05	6.74	6.02	5.9	6.36	7.19	8.26	
Bonding Overstretch (mm)		0.55	0.26	1.2	0.13	0.47	0.23	0.28	0.6	1.25	0.46	0.45	
Smartwire 1 Standard Template	Wire Loop Length	10.17	9.42	11.0	9.7	9.83	9.27	9.83	9.7	11.0	9.42	10.17	
	Loop Length Max Deflection	3.4	3.21	4.37	3.23	3.17	2.78	3.17	3.23	4.37	3.21	3.4	
	Loop Length Required	6.99	6.41	7.4	6.74	7.58	7.44	7.42	7.19	7.46	6.62	6.88	
Smartwire 2 Automated Custom	Wire Loop Length	8.75	8.7	9.97	8.68	8.68	8.73	8.68	7.55	8.9	8.59	8.71	
	Loop Length Max Deflection	1.8	1.96	2.81	2.0	2.04	2.25	2.04	1.04	1.87	1.88	1.78	
	Loop Length Required	6.74	6.31	8.14	6.46	6.77	5.92	6.54	7.02	8.2	6.59	6.58	

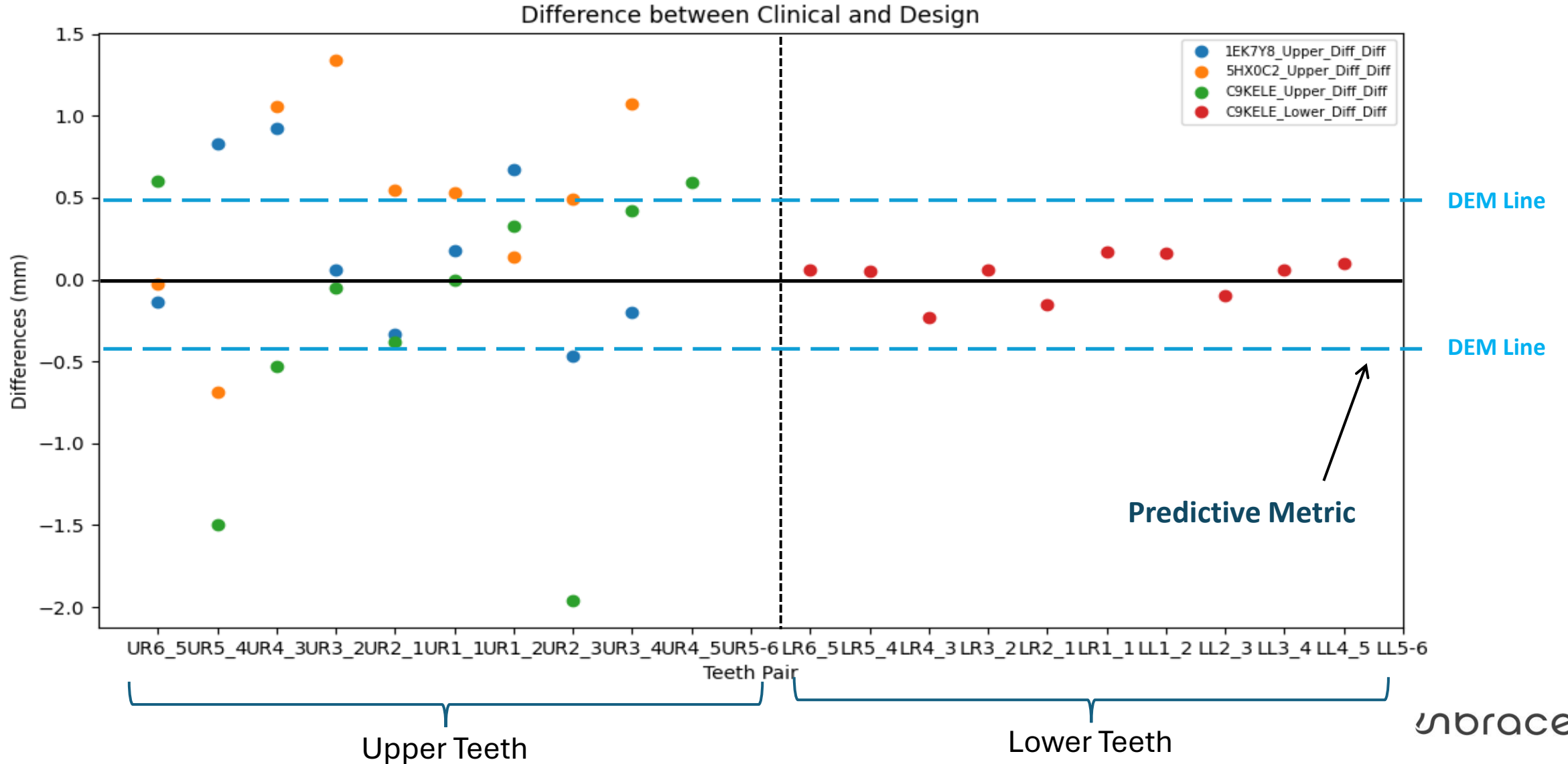
Python Codes and Data Analysis for 50 patients

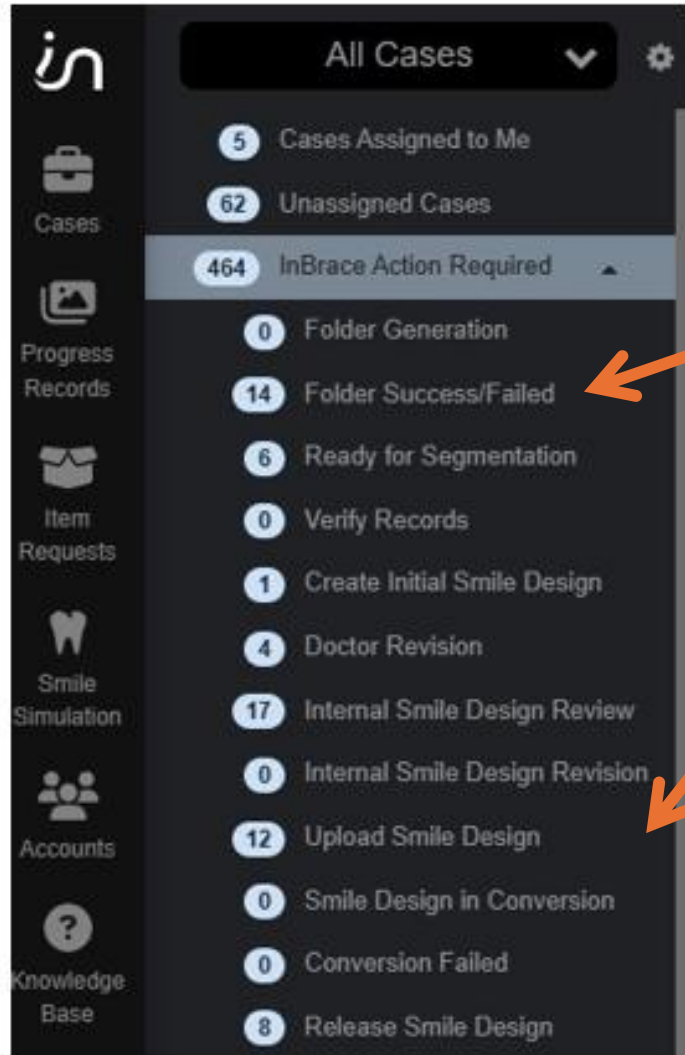
- Input_data_TEST
- Input_data
- Analysis_read_Excle_save
- Analysis_plots
- Analysis_Data_structure
- Analysis_Calculations
- Difference_Between_Clinical_and_Design
- Ave_Diff_Diff_Scatter_Plot
- Mal_Mal-DE_subtraction
- Diff_Diff
- Data_dict
- cleaned_trimmed_data
- Ave_Diff_Diff_modified
- Ave_Diff_Diff

```
1 import os
2 import pandas as pd
3 import matplotlib.pyplot as plt
4 import numpy as np
5 from io import StringIO
6
7 from typing import Tuple
8
9 # ----- Paths and Directories -----
10
11 # Get the script name (without extension) to use as the base for file names
12 SCRIPT_NAME = os.path.splitext(os.path.basename(__file__))[0]
13
14 # Define the base directory for input and output files
15 BASE_DIR = os.path.dirname(os.path.abspath(__file__))
16
17 # Define the folder where csv files are stored
18 INPUT_FOLDER = os.path.join(BASE_DIR, "Input_data") # Corrected folder path
19 print(f"Reading input files from folder: {INPUT_FOLDER}")
20
21 # Define file paths for output files directly in the same directory
22 INPUT_FILE = os.path.join(BASE_DIR, "process_malocclusion_processed_data.xlsx")
23 CLEANED_FILE = os.path.join(BASE_DIR, "cleaned_trimmed_malocclusion_data.xlsx")
24 PAIRWISE_FILE = os.path.join(BASE_DIR, "Mal_Mal-DE_subtraction.xlsx")
25 DIFF_DIFF_FILE = os.path.join(BASE_DIR, "Diff_Diff.xlsx")
26
27 # List all csv files in the input folder
28 file_paths = [os.path.join(INPUT_FOLDER, f) for f in os.listdir(INPUT_FOLDER) if f.endswith(".csv")]
29 print(f"Found {len(file_paths)} CSV files to process.")
30
31 # ----- Data Processing -----
32
33 # Function to read and process CSV files
34 def read_and_process_files(file_paths):
35     """
36     Reads and processes CSV files into a dictionary of DataFrames.
37
38     Args:
39     | file_paths (list): List of file paths to CSV files.
40     """
```

fatal: no email was given and auto-detection is disabled
2025-03-28 16:13:25.163 [info] > git config --get-all user.name [82ms]
2025-03-28 16:13:25.170 [info] [git][getRemotes] No remotes found in the git config file
2025-03-28 16:13:25.259 [info] > git config --get commit.template [92ms]
2025-03-28 16:13:25.259 [info] > git for-each-ref --format-%(refname)%00%(upstream:short)%00%(objectname)%00%(upstream:track)%00%(upstream:remotename)%00%

Monitoring Clinical Progression (individual patient's data)

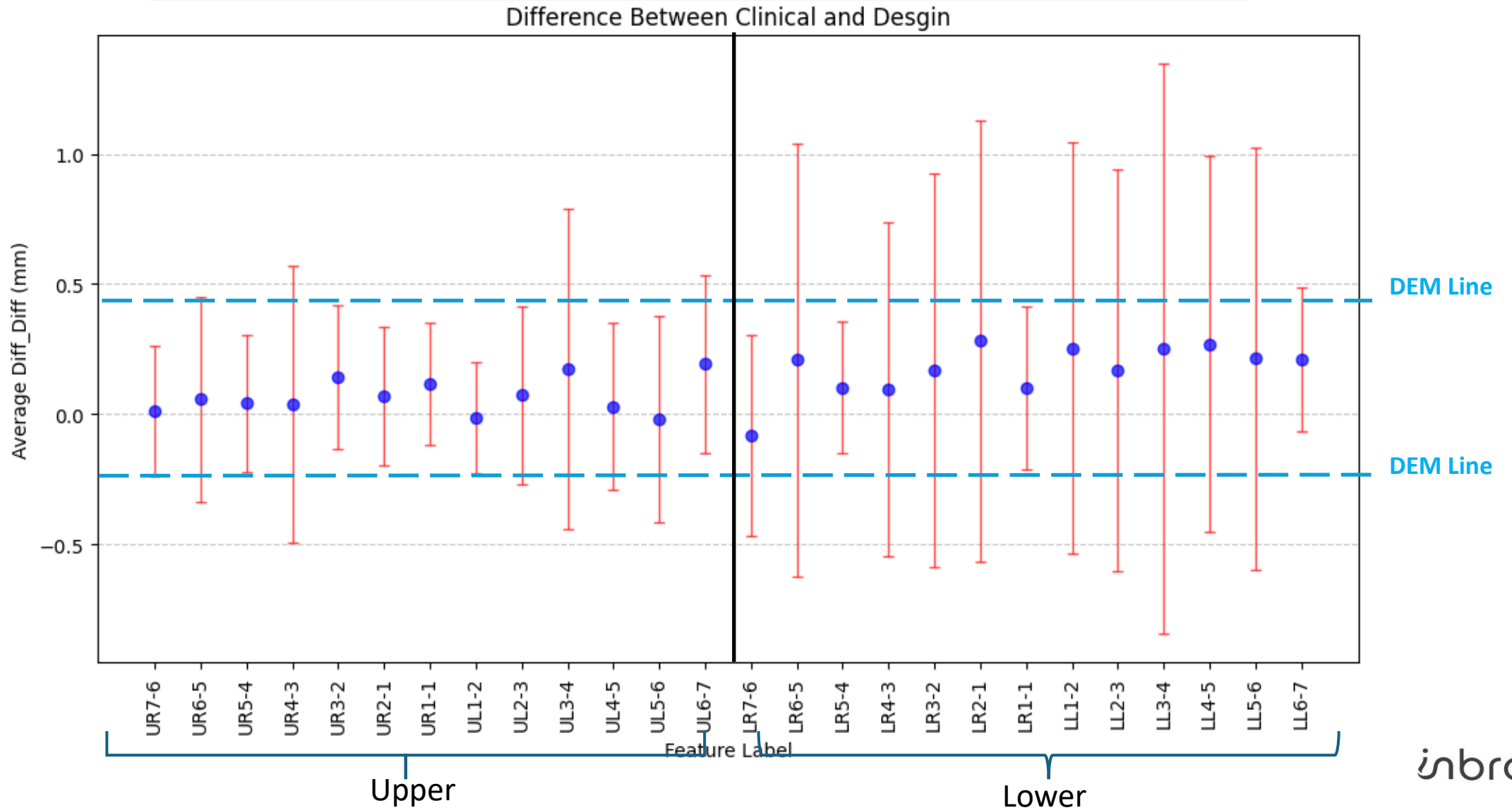




Predictive Metric

- Quantitative tool to reduce the cycle time by automating the clinical assessment and early monitoring the clinical output
- Help in detecting Early and False DEs
- Provides statistical data to monitor the progression and efficacy of treatment process during multiple DEs
- **Longer vision:** To enhance the design process by finding correlation between design rules, IFS, etc.

Product Performance Enhancement (50 patients)



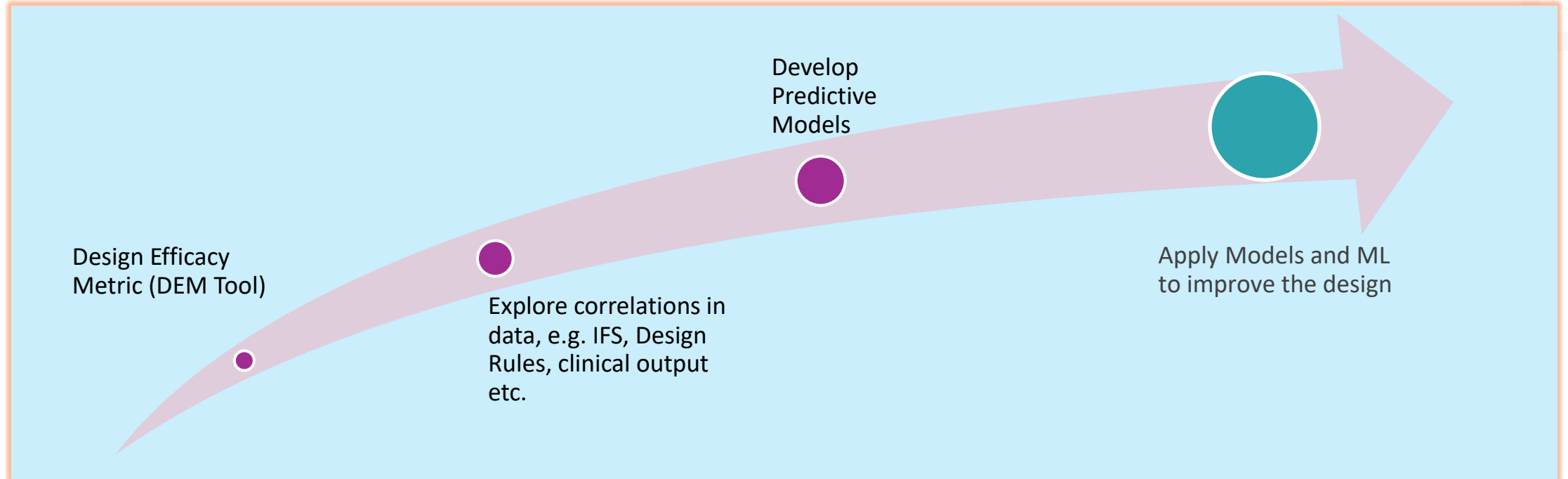
Analysis

- DEM predictor can be utilized for each patient to evaluate the treatment progression.
- A quantitative tool to enhance the decisions on DE implementation timeline, SW timeline or further analysis of the patient treatment plan.
- How can we integrate with clinical input (qualitative input)?
- How can we implement; as an app or in the software?

Questions:

- Can we find correlations between different metrics over large set of data and define a universal predictor model to design more effectively?
- How can we implement the predictor model to monitor the treatment outcome using scan data from devices like cellphone camera app (e.g. Grin scope) in near future?

Treatment Predictability and AI Model



Analysis next steps:

To create a pipeline to analyze a large set of cases (1000 patients):

- I. Restructure the analysis methodology to address this number of patients' analysis
- II. Update and develop the code and analysis methodology
- III. Utilize quantitative and qualitative metrics to analyze the outcome
- IV. Validating the process
- V. Reviewing the results
- VI. Recommendations and final implementations

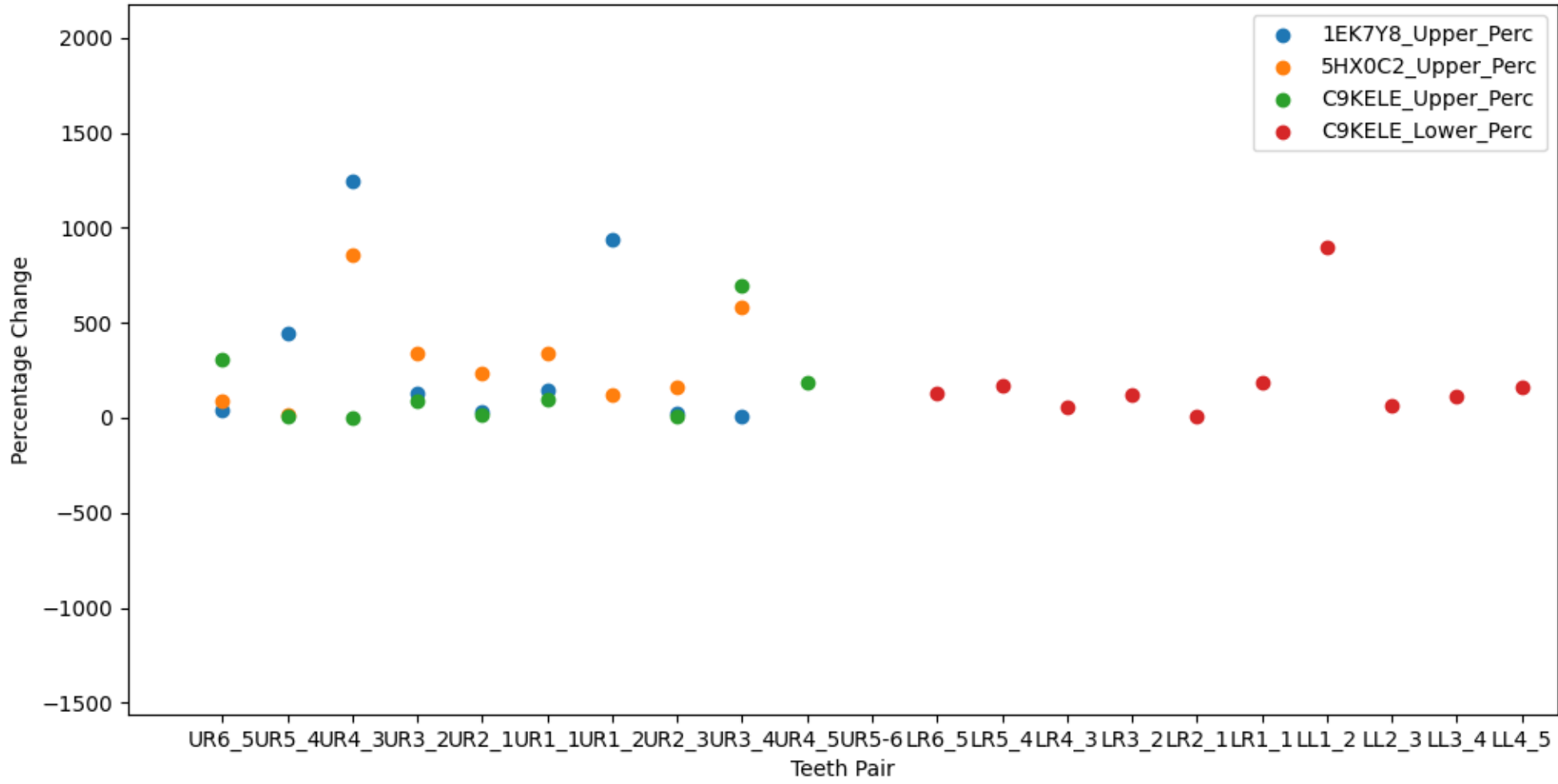
Thank you

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DEM Proposal Brief

Initiated by:	Amir Sajjadi
Problem statement:	How to reduce DE rate by calculating treatment outcome efficacy.
Proposed Solution	To calculate and compare the Pairwise Bracket Movements between Initial case and the Outcome at the time of DE and develop relevant predictive metrics.
Objective	Develop a Design Efficacy Measurement (DEM) tool to measure or predict treatment outcome based on the design input.

Malocclusion Percentage Changes



Additional Analysis with markers



